



Monitoring airborne concentrations of sporangia of *Phytophthora infestans* in relation to tomato late blight in Emilia Romagna, Italy

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Abstract

Late blight caused by *Phytophthora infestans* is one of the most important diseases of tomato crops in Emilia Romagna. In total, 7–8 chemical sprays are applied per season to control the disease without taking into account the risk of infection. An integrated warning service for the prediction of tomato late blight was set up in order to define a more rational disease control strategy. As a part of the warning service, a number of sites monitoring *Ph. infestans* airborne sporangia was set up for a timely disease prediction in the regional tomato growing areas. The results of 3 years monitoring of *Ph. infestans* sporangia are presented. They suggest that concentrations of airborne sporangia rapidly increase 1–2 weeks prior the blight onset in the field.

Keywords: Aerobiological monitoring; Forecasting; Fungal spores; *Ph. infestans*; Plant pathology

1. Introduction

Emilia Romagna is one of the leading Italian regions for tomato production. More than 17 000 out of 20 000 hectares of tomato crops produce roughly 1 000 000 tons of tomatoes for industrial processing.

Tomato late blight caused by *Phytophthora infestans* is the most important disease in the region. It is spread by sporangia produced on sporangiophores growing on infected tissues. Mature sporangia are then dispersed by wind and rain. When airborne sporangia arrive on stems, fruits or leaves of susceptible tomato plants, they germinate producing new infections. After a few days, new sporangia produced on newly infected tomato tissues are carried by the wind therefore spreading the disease to other tomato crops. The disease can spread rapidly as the time interval between the beginning of the infection and sporangia production is very short due to the particularly favourable climatic conditions in the area (Wallin, 1952, 1953). The resulting epidemics may lead to considerable yield losses.

Intense spray programmes are used to prevent and control the epidemics. The regional average number of

fungicide sprays per season is 7–8 and this represents 80% of the total chemical treatments applied to tomato crops. Nevertheless disease severity varies considerably from year to year and chemical sprays are routinely applied without taking into account the risk of infection.

In order to rationalize disease control strategies which limit the number of sprays on the crop while maintaining a high quality production with consequent environmental and farmer protection, many epidemiological studies on climatic conditions influencing disease outbreaks have been done. Several climatic-based forecasting models have been developed. In 1991 the Emilia Romagna region set up a warning service to predict the occurrence of tomato late blight (Bugiani et al., 1992). The warning service makes use of the I.P.I. (Infection Potential Index) climatic-based forecasting model developed by the regional Plant Protection Service in 1990. The model gives 'negative prognosis' predictions about the potential risk of blight occurrence on the basis of climatic data recorded by weather stations located throughout the region (Ponti et al., 1991). However, the model does not take into account inoculum potential in the different tomato growing areas. Airborne sporangia can be used to evaluate inoculum potential within tomato growing areas and to predict the risk of infection and the most probable time of blight occurrence in the field

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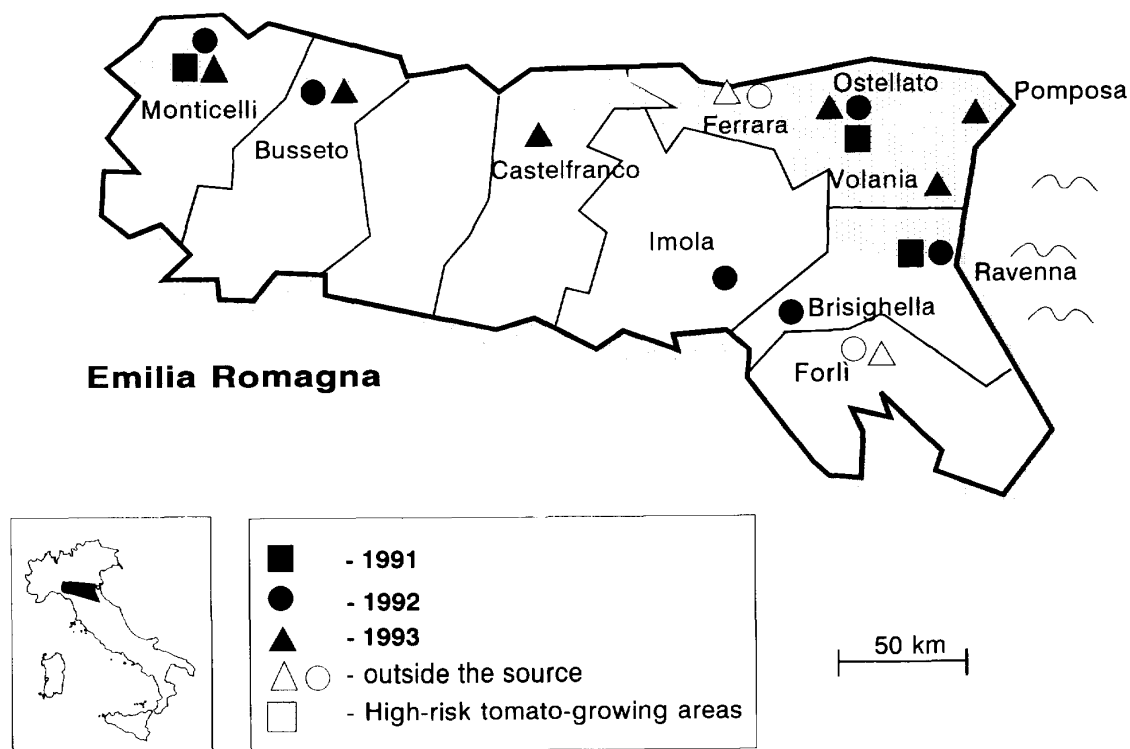


Fig. 1. Maps of the sampling sites in Emilia Romagna region for the years 1991, 1992 and 1993.

Table 1
Monthly wind direction at sampling sites for the years 1991, 1992 and 1993

Sampling site	Monthly mean wind direction			
	May	June	July	August
1991				
Ravenna	South-east	South-east	East	East
Piacenza	North-west	West	West	West
Ostellato (Ferrara)	South-west	South-west	East	East
1992				
Ravenna	East	West	East	East
Piacenza	North	North-west	West	West
Ostellato (Ferrara)	East	South-west	North	—
Ferrara	East	West	East	East
Imola (Bologna)	—	South-west	South-west	South-west
Parma	—	West	South	South-west
Brisighella (Ravenna)	—	South-west	South-west	South-west
Forlì	East	South-west	East	South-west
1993				
Volania (Ferrara)	South-west	East	East	East
Pomposa (Ferrara)	—	—	East	North-west
Ostellato (Ferrara)	West	East	East	East
Ferrara	West	East	East	East
Castelfranco (Modena)	—	—	South-west	South-west
Parma	West	East	West	West
Piacenza	West	East	West	West
Forlì	South-west	South-west	East	East

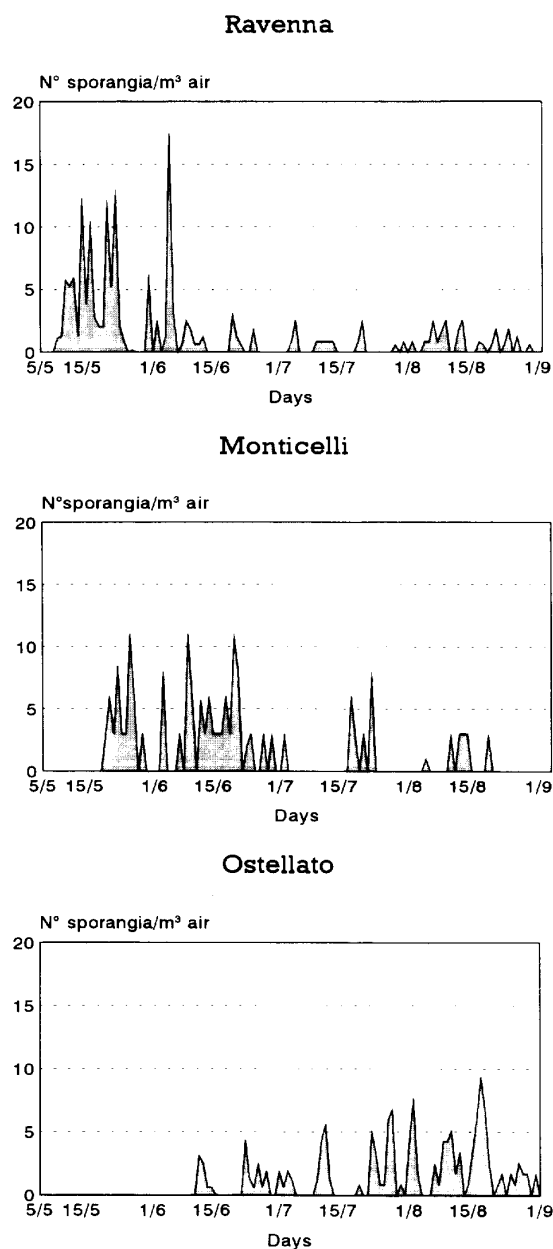


Fig. 2. Airborne concentration of *Ph. infestans* sporangia for selected sites during the tomato growing season in 1991. Spore monitoring in Ostellato started on 1 June.

(Gregory, 1973; Bugiani and Govoni, 1991; Picco, 1992). Moreover, a regional network of unsprayed tomato plots was set up to check the correctness of the aerobiological monitoring and give a more precise warning. Integration of data obtained by these three forecasting tools provides farmers with information on

the right time for treatment together with the most suitable chemical product. This paper reports the results of monitoring airborne concentrations of *Ph. infestans* sporangia in unsprayed tomato plots susceptible to the disease at different sites and their relation with the moment of the first blight occurrence in the area.

2. Materials and methods

To evaluate the feasibility of aerobiological monitoring providing information on the risk of crop infection and predicting blight occurrence in tomato growing areas, some volumetric sporetraps (Hirst trap, Lanzoni VPPS 2000) (Hirst, 1952) were placed inside some of the unsprayed tomato plots (Fig. 1). Following the 1990 experience where a sporetrap was placed in Ravarino and Monticelli in the provinces of Modena and Piacenza, respectively (Ponti and Cavanni, 1992), more monitoring stations were added the following years. In 1991, three sites were used: Monticelli, Ostellato, and Ravenna, while in 1992 three more sites were added: Imola, Busseto and Brisighella. In 1993, in order to concentrate on the tomato growing areas in Ferrara province, three sporetraps were placed in Ostellato, Pomposa and Volania while another three were set up in the western provinces of the region: Castelfranco, Monticelli and Busseto. All the sporetraps were placed at a height of 1.5 m above ground level and within the possible natural source of inoculum represented by the unsprayed tomato plots. Furthermore, in order to evaluate the feasibility of extending the prediction to wider areas, in 1992 and 1993, the concentration data of sporangia were provided by two sporetraps placed 15–20 m above the ground and located in Ferrara and Forlì far from the source of inoculum. The two stations belong to the Regional Network of Aerobiological Monitoring. Spore concentrations were determined with a Zeiss microscope fitted with a $\times 25$ objective. The sporetraps sampled at 10 l/min. The amount of *Ph. infestans* sporangia was related to blight occurrence in the unsprayed tomato plots.

Each unsprayed plot measured 100 m². They were planted early in mid-April with the tomato cv. Heinz, highly susceptible to the disease and checked weekly by field technicians for the first symptoms of the disease occurring in the field.

3. Results

In 1991, all the sporetraps measured very low spore concentrations throughout the season (below 20 sporangia/m³) and no epidemics were recorded on the unsprayed tomato plots nearby (Fig. 2). In 1991, no blight outbreaks were recorded in the regional tomato growing areas.

In 1992 at the sites in Ostellato and Monticelli, from

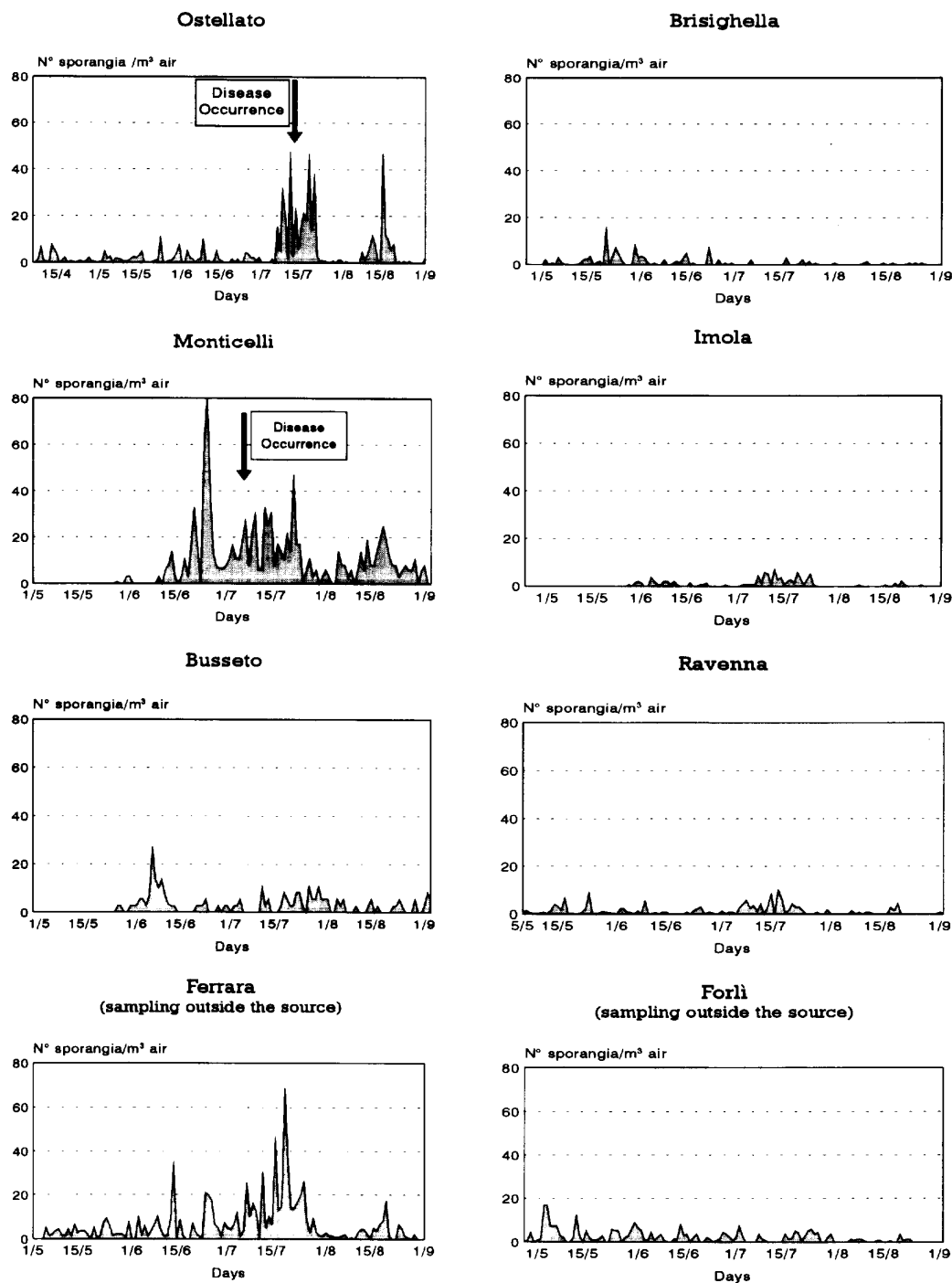


Fig. 3. Airborne concentration of *Ph. infestans* sporangia for selected sites during the tomato growing season in 1992. Spore monitoring in Monticelli, Busseto and Imola started on 25 May.

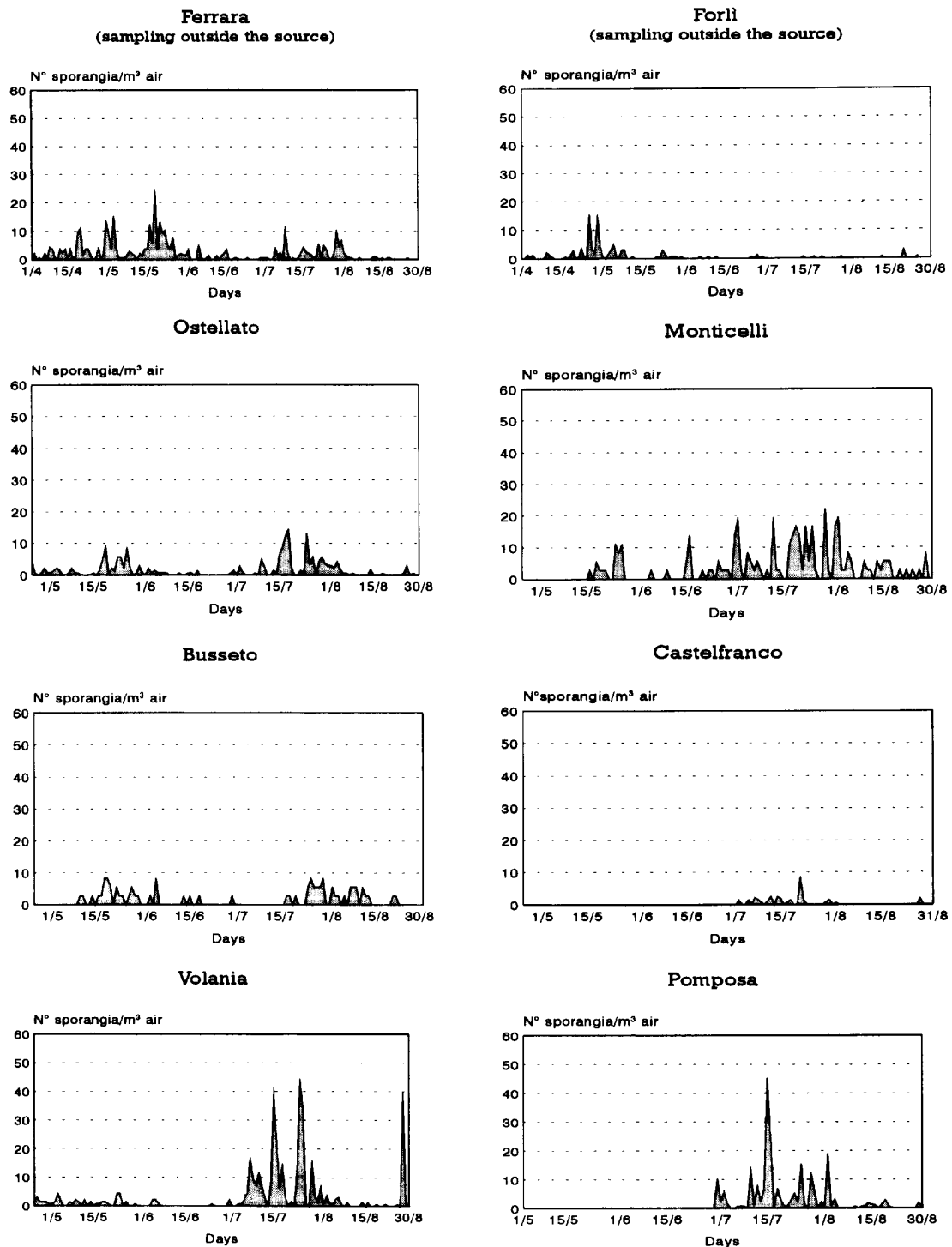


Fig. 4. Airborne concentration of *Ph. infestans* sporangia for selected sites during the tomato growing season in 1993. Spore monitoring in Castelfranco and Pomposa started on 1 July. Volania, first symptoms of the disease occurred on 27 July without any epidemic spread. Pomposa, first symptoms of the disease occurred on 10 August without any epidemic spread.

late June spore concentrations often exceeded 40 sporangia/m³ and in Monticelli a peak of 80 sporangia/m³ was measured on 28 June. Blight epidemics occurred 1–2 weeks later in tomato growing areas nearby. In contrast, in the other provinces the local monitoring sites recorded low spore concentration throughout the season. Concentrations exceeding 10 sporangia/m³ were found in the second decade of July only and no disease outbreaks occurred in the unsprayed plots of that tomato growing area. Concentration patterns measured at the monitoring stations in Ferrara and Forlì, far from the source of inoculum, were similar to equivalent sites close to sources suggesting a wider scale increase of inoculum (Fig. 3).

In 1993, as in 1991, concentrations of airborne *Ph. infestans* sporangia were low and there were no disease outbreaks throughout the season in all the regional tomato growing areas. Two of the four sporetraps in the province of Ferrara recorded a peak concentration greater than 40 sporangia/m³ in mid-July followed by the occurrence of the first symptoms of the disease in the unsprayed tomato plots. However, the epidemics failed to spread probably because the climatic conditions were unfavourable for the pathogen — a prolonged dry period and very high maximum temperatures (Fig. 4).

4. Discussion and conclusions

In 4 years of investigations on tomato late blight, on the four occasions when *Ph. infestans* airborne concentrations in unsprayed plots exceeded about 40 sporangia/m³, disease epidemics were reported in the local tomato growing areas 1–2 weeks later. This suggests that inoculum monitoring may be a useful predictor of the onset of the disease. Aerobiological monitoring could be a key tool within the Blight Warning Service because it enhances the information provided by the I.P.I. mathematical forecasting model and the network of unsprayed tomato plots. As a matter of fact, information from aerobiological monitoring is taken into account particularly when the 'Infection Potential Index' of the model reaches the threshold of blight risk. From that moment on, every climatic event favourable for the disease may lead to disease outbreaks. Once the threshold is crossed, the monitoring of airborne pathogen propagules concentrations can be useful for a more precise prediction of disease occurrence. Results obtained so far by the Blight Warning Service made it possible for farmers to save on average 50% of chemical sprays and sometimes 80% in those years unfavourable for blight occurrence (Bugiani et al., 1992).

The prevailing wind in the Western provinces was west-south-west and in the Eastern provinces (e.g. Fer-

rara) easterly; the westerly component decreased from the coast to the inland part of the region (Table 1). Thus, the sporetrap, far from the source of inoculum in Ferrara was in a good position to monitor the inoculum coming from the east, i.e. one of the tomato growing areas which lies to the east of the site. On the other hand, the sporetrap in Forlì was not suitable for detecting airborne inoculum as most of the winds blow from the south and east, where no tomato crops are commonly grown. Western provinces are commonly considered high blight risk areas, and as they are influenced by west winds, monitoring of airborne *Ph. infestans* sporangia at sites outside a source of inoculum should be investigated. Nevertheless, in spite of the fact that monitoring stations placed within unsprayed plots appear to be useful in highlighting the risk within nearby tomato growing areas, further studies on their applications to large areas is still necessary. On the other hand, results obtained from sporetraps placed far from the source of inoculum might be useful provided that they are sensibly sited. So, further comparison between sporetraps sited within or far from the source of inoculum are needed.

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